Bürger, Raimund; **Karlsen, Kenneth H.**; **Towers, John D.**

Closed-form and finite difference solutions to a population balance model of grinding mills.

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Summary: The wear of steel balls in continuously operated grinding mills, used in mineral processing to comminute metalliferous rocks, can be described by a simple population-balance model. This model gives rise to a scalar transport equation with a singular source term for the number density of balls as a function of size and time. Exact solutions to this equation are determined under the assumption of a simple power-law type wear law. It is shown that a particular term proposed in the engineering literature that describes the removal of used balls from the mill leads to negative solutions (model 1). An alternative, more realistic term for the sieve action, which admits nonnegative solutions only, is introduced (model 2). A working first-order finite-difference scheme for model 2 and a second-order TVD variant are introduced and applied for numerical simulations along with an error study. A weak solution concept for model 2 is proposed, uniqueness of weak solutions is shown, and convergence of the first-order scheme to a weak solution is established. These results hold for a general class of wear laws, not just power-law type.

MSC:

74M15	Contact in solid mechanics
74H05	Explicit solutions of dynamical problems in solid mechanics
74S20	Finite difference methods applied to problems in solid mechanics
80M20	Finite difference methods applied to problems in thermodynamics and heat transfer
65M06	Finite difference methods for initial value and initial-boundary value problems involving PDEs
82C70	Transport processes in time-dependent statistical mechanics
92D25	Population dynamics (general)

Keywords:

TVD scheme; uniqueness; existence; weak solution

Full Text: DOI

References: